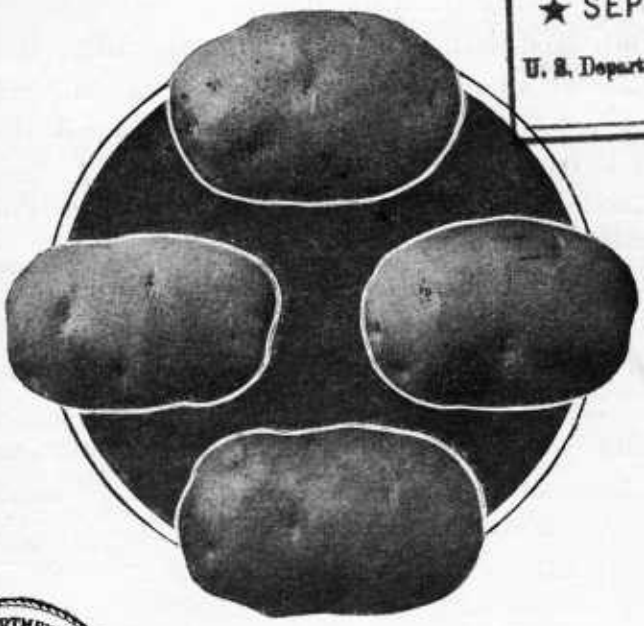
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1332 rev. June 1929.

Rev. ed. follows

SEED POTATOES AND HOW TO PRODUCE THEM



THE AVERAGE PRODUCTION per acre of potatoes in the United States is very much lower than in Canada, Great Britain, and European countries outside of Italy.

One of the reasons for the lower production in the United States is that less attention has been given to the character of the seed. Good seed is one of the determining factors in the production of maximum crops of potatoes.

The use of high-grade seed would increase the returns from the potato crop of the country by many millions of dollars.

The quality of the seed may be improved through the removal of all diseased, weak, or off-type plants as soon as they are observable.

Only seed from productive plants should be used.

Careful attention should be given to procuring seed that is free from varietal mixture and that is true to type.

Good seed can not be produced unless the growing plants are given good cultural attention.

As a rule the quantity of seed used is not sufficient to produce a maximum crop.

From 15 to 18 bushels of seed should be used per acre instead of 9 to 11, as at the present time.

All seed stock should be disinfected before planting.

Good storage conditions are essential to insure sound, firm seed at planting time.

This bulletin is a revision of and supersedes Farmers' Bulletin 533, "Good Seed Potatoes and How to Produce Them."

Washington, D. C. Issued May, 1923; revised June, 1929

SEED POTATOES AND HOW TO PRODUCE THEM

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YIELDS OF POTATOES

A STUDY of the statistical data upon potato-crop production in the United States for the last 60 years reveals the interesting fact that relatively little gain in production per acre has been made except during the last few years of this period.

To minimize partially seasonal variations in yield per acre the 60-year period [1] has been divided into twelve 5-year cycles and the average production of each cycle compared. During the first 5-year cycle, 1868 to 1872, the average yield per acre was 94.5 bushels, whereas in the last 5-year period it was 113.7, or a gain of approximately 20.3 per cent. The averages for the twelve 5-year cycles are 94.5, 88.1, 77.9, 76.7, 74.0, 79.9, 82.2, 96.3, 96.5, 96.0, 98.9, and 113.7 bushels per acre, respectively. A study of these data show that there was a very appreciable and more or less gradual decline in production per acre during the second, third, fourth, and fifth cycles, or from 1875 to 1892, and that during the next three cycles there was a decided increase. From this period until the 1918–1922 cycle the increase was a very nominal one, but during the 1923–1927 cycle the increase was very marked. In fact, as compared with the 1918–1922 acreage, it shows an increase of nearly 15 per cent.

It is possible to account for this striking increase in production per acre only by assuming that it is largely due to a more general use of

[1] The statistical data upon which these studies are based were obtained for the years 1868 to 1888 from the United States Department of Agriculture Yearbook for 1917, p. 657; for 1889 to 1895 from the 1920 Yearbook, p. 617; for 1896 to 1920 from the 1921 Yearbook, p. 583; and for 1921 to 1922 from the Dec. 23, 1922, issue of the United States Department of Agriculture Weather, Crops and Markets publication, p. 565; for 1923, 1924, and 1925 from the 1926 Yearbook, p. 934; and for 1926 and 1927 from Crops and Markets, Dec., 1927, p. 460.

certified seed potatoes and to the gradual improvement in the quality of the seed produced. The total average bushel production in the United States in the 5-year cycle 1868 to 1872 was 117,745,800, whereas in the last two periods, 1918–1922 and 1923–1927, the production was 390,615,600 and 383,526,400 bushels, respectively. Expressed in percentages, the increases were 231 and 225.7 per cent. During this same period the acreage increases were 217 and 154.5 per cent, respectively. These data show rather conclusively that up to the last 5-year period increased total production has been due to increased acreage rather than to increase yield per acre. This does not apply to the last cycle, 1923 to 1927, as it is clearly evident that the increased production was due to a larger acre yield brought about by improved cultural practices.

Table 1 and the accompanying diagrams (figs. 1 to 3) show the average acre yields, the farm price per bushel, the acreage grown, and the total production of potatoes, while Figure 4 shows the population of the United States during the eleven 5-year cycles studied. In the construction of these diagrams it has not been feasible to employ the same scale in any two of them, owing to the great difference in the magnitude of the figures treated. A careful study of the first diagram (fig. 1), in which the acreage yield and farm price per bushel are given, shows that the acreage-production curve, if drawn on the chart, would somewhat resemble the curve of a scimitar blade, in which the extreme ends of the blade represent the maximum yields for each half of the curve.

TABLE 1.—*Averages of acreage, production, and farm values of potatoes in 5-year periods from 1868 to 1927, inclusive*

Five-year period	Number of acres	Production (bushels)		Farm value on Dec. 1	
		Total	Per acre	Total	Per bushel (cents)
1868 to 1872	1,246,200	117,745,800	94.5	$64,123,600	54.5
1873 to 1877	1,529,800	134,773,200	88.1	68,665,600	50.9
1878 to 1882	1,934,200	150,706,200	77.9	85,547,200	56.8
1883 to 1887	2,284,000	175,197,800	76.7	82,295,000	46.9
1888 to 1892	2,633,800	194,939,400	74.0	93,012,600	47.7
1893 to 1897	2,900,400	231,757,800	79.9	95,258,400	41.1
1898 to 1902	2,968,200	243,866,400	82.2	117,671,600	48.3
1903 to 1907	3,213,200	309,568,200	96.3	170,652,800	55.1
1908 to 1912	3,644,400	351,793,800	96.5	213,038,200	60.6
1913 to 1917	3,812,400	366,045,600	96.0	322,292,400	88.0
1918 to 1922	3,948,400	390,615,600	98.9	425,975,400	109.1
1923 to 1927 [1]	3,372,400	383,526,400	113.7	416,232,000	108.5

[1] Data for 1927 are subject to correction.

The gradual decline in yields during the first half of this period is thought to be largely due to the following factors:

The ravages occasioned by the Colorado potato beetle during the early period of its invasion of the eastern United States.

The financial depressions of 1877 and 1893, which brought about a well-marked decline in agriculture in New England, New York, and the other heavy potato-producing areas of the northeastern United States.

A gradual depletion of soil fertility.

Of the factors which have checked the downward tendency and contributed most largely toward a return to the old production level the following are thought to have been most potent:

The influence of the agricultural experiment stations, agricultural colleges, and the United States Department of Agriculture through experimentations, demonstration, and the dissemination of literature.

The influence of the Bordeaux-mixture treatment in the control of fungous diseases affecting the potato.

The development of special potato-growing sections, as, for example, Aroostook County, Me., the Atlantic Coastal Plain trucking region, the Greeley and Carbondale districts of Colorado, and many other areas, in which the average yield is approximately from two to three times the general average for the United States.

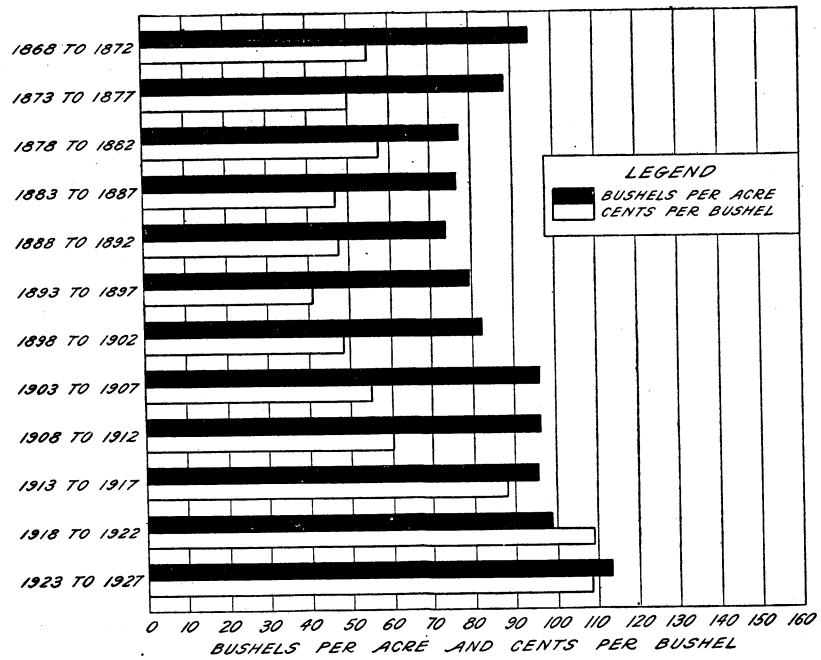

FIGURE 1.—Diagram showing the average number of bushels per acre and the average farm price per bushel of potatoes grown in the United States by 5-year periods from 1868 to 1927

Figures 1 to 4 show a comparison of the relation of increased production to a constantly increasing population. The diagrams show that under normal conditions production is keeping pace with population. Crop shortages are, therefore, the result of abnormal or unfavorable conditions.

In comparing the average crop production of potatoes in the United States with that of Great Britain, one is impressed with the fact that generally speaking we have much yet to learn before we can raise our average to that of that country. During the years 1901 to 1910, inclusive, the average acre yield in Great Britain was approximately 200 bushels, while that in the United States was not quite 93 bushels.

Of the many causes that produce a low average yield in the United States, poor seed is thought to play an important part. As a rule

the North American potato grower does not pay as careful attention to the seed potatoes he plants as does the European grower. The quality of seed demanded by European potato growers has been largely responsible for their differentiation into seed specialists and crop specialists. The seed specialist makes a business of producing

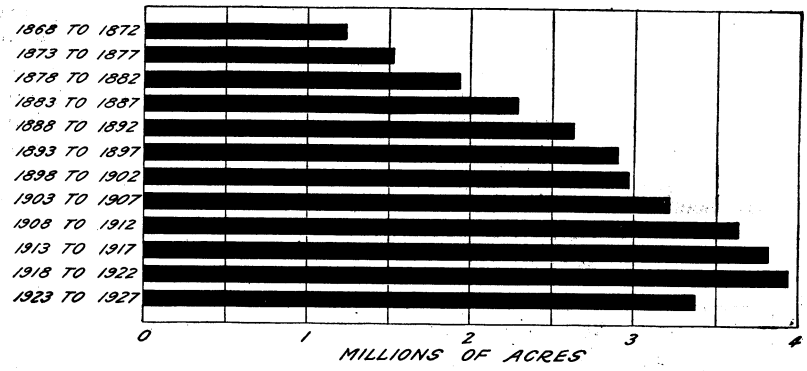

FIGURE 2.—Diagram showing the average potato acreage of the United States by 5-year periods from 1868 to 1927

high-quality seed; the crop specialist produces a high-grade table potato. Until recently no such differentiation, at least to any marked extent, could be claimed in this country. Fortunately, with the rather general adoption of a seed-potato inspection and certification service by most if not all northern seed-potato producing States, there has come a much more widespread use of certified seed pota-

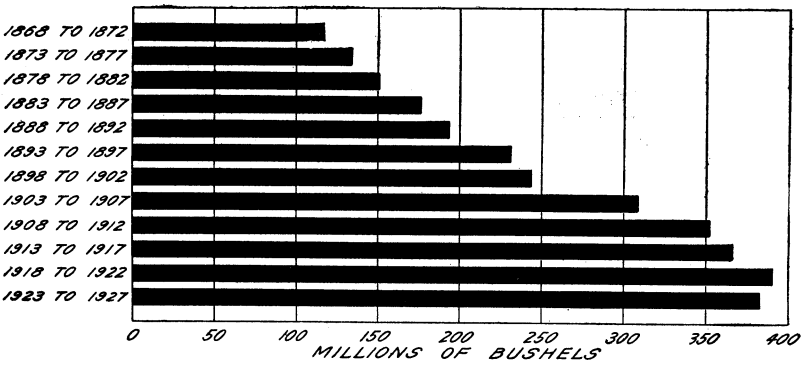

FIGURE 3.—Diagram showing the average potato production of the United States by 5-year periods from 1868 to 1927

toes and as a result a keener appreciation on the part of progressive growers of the real importance of good seed stock. This is resulting in an increased demand for certified seed potatoes, in consequence of which those who are engaged in the production of high-class seed are receiving a handsome premium for it.

WHAT CONSTITUTES GOOD SEED

Two factors are involved in the consideration of good seed potatoes: (1) The physical or outward appearance of the tubers and (2) the heritable or transmissible characters of the stock. The first involves the purity and maturity of the stock, uniformity in size and shape of the tubers, brightness of skin, firmness of flesh with first sprouts just showing, and freedom from scab, Rhizoctonia, late blight, or other tuber-decay diseases. The second factor deals with nonobservable characters and is by far the more important one, as it involves the presence or absence of the virus diseases causing mosaic, leaf roll, spindle tuber, streak, and yellow dwarf. Freedom from the virus diseases is an important consideration and can only be assured through personal inspection of the growing plants from which the seed was obtained or by the purchase of reliably certified stock. If in any given year it were possible to plant the entire potato acreage of the United States with first-class seed stock the total pro-

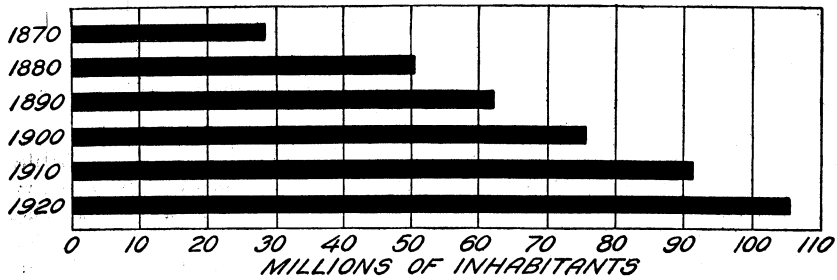

FIGURE 4.—Diagram showing the population of the United States by decades from 1870 to 1920

duction would be increased from 10 to 25 per cent. Based on the average production for the 5-year period from 1918 to 1922, this increase would represent from 39 to 97½ million bushels, or an increase in money value of $40,333,000 to $106,333,000.

CERTIFIED AND UNCERTIFIED SEED

The rapid increase in acreage and production of certified seed potatoes, together with the premium over uncertified seed demanded by the grower for such stock, has made it necessary to demonstrate its superiority over ordinary seed. In the early and consequently developmental period of seed certification the producers' claims of superiority were not sufficiently well supported by experimental evidence to make them convincing. To-day there is abundant evidence of the general superiority of certified over uncertified seed potatoes. In a paper presented at the 1924 annual meeting of the Potato Association of America, H. C. Moore, of the Michigan Agricultural College, submitted data covering actual comparative tests by a large number of independent investigators, as shown in Table 2.[2]

[2] MOORE, H. C. EVIDENCE THAT CERTIFIED SEED IS IMPROVED SEED. Proc. 11th Ann. Meeting, Potato Assoc. America, 1924, p. 28. 1925.

These and many other data serve to emphasize the value of high-grade seed. They also indicate the general superiority of certified over noncertified stocks as a source of good seed.

TABLE 2.—*Comparative tests of potato yields, showing the advantage of using certified seed*

Location of tests	Number of tests or reports	Average increase in yields per acre (bushels)	Location of tests	Number of tests or reports	Average increase in yields per acre (bushels)
Canada (8 Provinces)	15	88	Michigan	314	73
Connecticut	144	53	Missouri	46	43
Delaware	21	83	Montana	2	219
Illinois	15	47	Nebraska	64	141
Indiana	9,740	44	New York	68	76
Kansas	11	41	Ohio	168	48
Kentucky	220	42	Oregon	3	150
Louisiana	31	42	Pennsylvania	87	41
Maine	279	83	South Carolina	8	31
Massachusetts		75			

UNIFORMITY IN SIZE AND SHAPE OF TUBERS

Under normal conditions of growth many present-day commercial varieties are very variable in size and shape of tuber. To some extent both size and shape are determined by the character of the soil, rate of planting, fertilization, and cultural care given the growing crop. Inheritance, however, plays a very important part. Most varieties contain within themselves distinct varietal strains which when isolated are much more uniform in respect to size and shape than the variety itself. Other things being equal, the variety or varietal strain that produces the greatest number of fair-sized shapely tubers and the smallest number of ill-shaped and small tubers should prove the most valuable, because it involves less waste to both the grower and the consumer. It is particularly important at present that such strains be developed, because there is an increasing demand for fancy table stock to satisfy the requirements of a large and discriminating class of consumers who are insisting on greater uniformity in size and shape and are willing to pay a premium on such grades.

DEVELOPMENT OF HIGH-GRADE SEED POTATOES

The successful production of high-grade seed potatoes is very largely dependent upon the following factors: (1) Starting with a good strain; (2) the proper treatment of the seed; (3) thorough preparation and proper fertilization of the soil; (4) the following of the best cultural practices, including protection against insect and fungous pests; (5) the elimination of all mixtures and all diseased or weak plants; and (6) the careful harvesting and proper storage of the crop.

SECURING A GOOD STRAIN OF SEED

If the strain of seed being used is lacking in vigor, it is generally advisable to discard it and purchase a new lot from some reliable grower having superior stock. This suggestion is made as the re-

sult of a rather wide experience in trying to improve poor strains of potatoes through selection methods. Such attempts have usually resulted in failure, and it is felt that as a rule much more satisfactory progress can be made by starting with a new strain. Further improvement can usually be secured through selection.

IMPROVEMENT BY SELECTION

The improvement of seed potatoes by selective processes has long engaged the attention of the potato grower. Recent experimental evidence seems to indicate that the possibilities of improving potato seed stock by selective processes alone are not as great as many writers upon this subject have claimed. To those who have devoted much time and effort to the improvement of the potato by selection it would appear that the chances of finding superior yielding true-to-type strains within a variety are not as great as has been believed. The chief advantages to be derived from seed-potato selection practices are the elimination of diseased and weak plants and the removal of varietal mixtures.

IMPROVEMENT PRACTICES

Six improvement practices may be used in obtaining a commercially desirable strain of potatoes, namely: (1) The tuber-indexing method, (2) tuber-unit method, (3) hill selection, (4) mass selection, (5) field roguing, and (6) strain testing.

TUBER-INDEXING METHOD

The tuber-indexing method of seed-potato improvement is the most recent as well as most effective method of eliminating diseased, weak, and low-yielding potato tubers from seed stock intended for planting in the seed plot. It is usually done during the winter season. The usual procedure in the employment of this method is to select as many tubers weighing from 7 to 9 ounces or thereabouts as greenhouse, hotbed, or outdoor space will permit. The next step is to number each tuber for identification purposes and then remove a seed piece or set from each one, preferably from the seed end, although any strong eye will serve the purpose. This set is then put in a suitable-sized pot (the 3½ or 4 inch size is satisfactory), or it may be planted in a greenhouse bench or hotbed. In either case the pot or set in the bench must be labeled with the number of the tuber from which it was taken. The plants produced from these seed pieces are carefully observed for the presence of virus diseases such as the various types of mosaic, leaf roll, spindle tuber, giant hill, and yellow dwarf. All plants showing the presence of any of the diseases mentioned as well as any sign of weakness are noted and the seed tuber from which the set was taken is discarded. In this way, by close observance of the plants, it is possible to get rid of most if not all of the diseased tubers prior to planting them.

The extent to which this work can be conducted in the North, except in regions where a late or fall crop of potatoes can be grown, is necessarily limited to the greenhouse or hotbed space available for the work. Where a fall or second crop is grown, as in southern

New Jersey, the Eastern Shore of Maryland or Virginia, and practically all of the Southern States, it is possible to practice the tuber-indexing method with the spring crop by planting the set from the numbered tuber in the open field and properly labeling it. Readings can be taken during the growing season in ample time for a second-crop planting of indexed tubers that are apparently free from disease as well as from any inherent weakness. By undertaking such work in the far South it would be possible to grow the indexed sets to full maturity before the normal planting period in the North. In fact, certain State seed certification agencies are now resorting to this practice in order to get a "reading" on the behavior of their certified strains of seed potatoes. It is believed that the day is not far distant when most of the States offering seed certification will be practicing this method of seed-potato improvement. The tubers found to be free from disease are planted at the proper time in a seed plot by themselves on the tuber-unit basis in order to make it easy to identify the presence of disease in the plants from any infected tuber that may have escaped the observer of the tuber-indexed set. From this point the same methods are practiced as in the tuber-unit method, the description of which follows.

TUBER-UNIT METHOD[3]

The tuber-unit method, as now generally understood, consists in selecting from the seed bin before planting time a considerable number of the most perfectly shaped tubers ranging from 6 to 8 ounces in weight. In planting, these tubers are quartered, as dropped, into parts as nearly equal as possible, by splitting the bud-eye cluster twice from seed to stem end of the tuber. In other words, the tuber is cut through its longitudinal axis. The four pieces of each tuber are dropped consecutively in the row at a distance of 10 to 12 inches apart in the furrow. All tubers showing discoloration of the flesh or other evidence of disease should be rejected. By allowing an additional spacing between sets of fours, the four plants from each tuber are definitely isolated from adjoining ones and the grower can readily observe any variation in vigor and uniformity among the various units planted. This method also enables him to detect any mixtures that may occur in the variety. All mixtures should be removed at once. By marking the units that appear to be the most uniform in size, vigor, and type when the plants are still in vigorous growth, the first step in selection has been accomplished. At digging time the product of each unit is separately harvested and a further selection made from the marked units of all tubers which most nearly approach the size, shape, and smoothness desired. The selected tubers of each unit should be separately placed in small sacks, preferably cotton or burlap, numbered with both field and unit numbers, and stored to await further examination. The final examination should produce data on the number and weight of merchantable and unmerchantable tubers and their general conformity in size, shape, and smoothness of the type desired. From

[3] For further information concerning the arrangement of a tuber-unit selection plot and a convenient system of note taking, see the following publication: STUART, WILLIAM. THE "TUBER-UNIT" METHOD OF SEED-POTATO IMPROVEMENT. U. S. Dept. Agr., Bur. Plant Indus. Cir. 113, pp. 25–31, 2 figs. 1913.

each of the units retained 10 of the best tubers should be selected for the next season's planting.

It is desirable to maintain the study of each selection on the tuber-unit basis the following season, because it permits a more accurate comparison of the behavior of each. The 10 selected tubers from each original unit will give 40 plants for study the second year. All selections which do not produce a reasonably uniform lot of plants should be marked for rejection. At harvest time the progeny of each selection should be kept by itself and the same data recorded as those taken on the crop grown from the original tuber unit. Only the products from such 40-hill rows as meet the most rigid requirements should be retained. The further conduct of the work will consist in

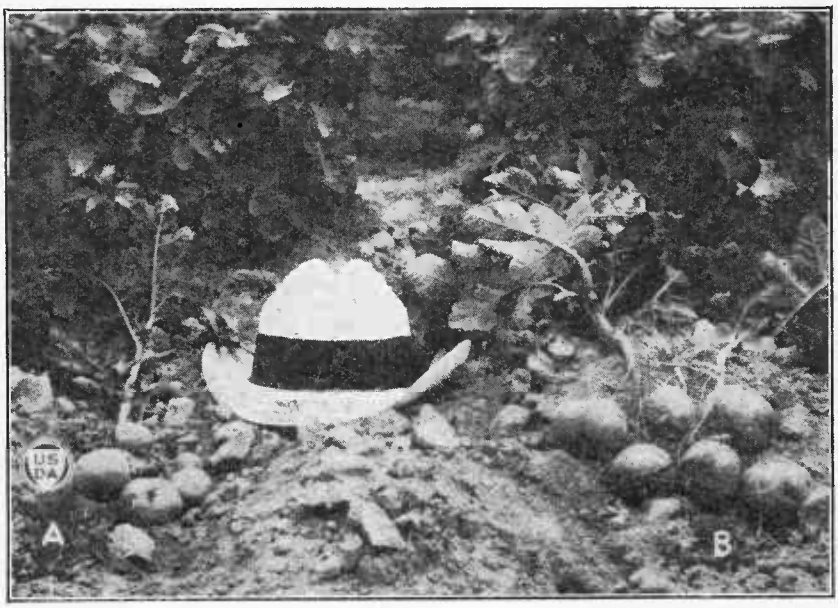

FIGURE 5.—Progeny of a mosaic-infected potato plant of the Triumph variety on the left (A) and of a healthy plant on the right (B). Bin selection of such seed would result in taking at least two tubers from the mosaic plant. If small tubers were used all would come from diseased plants. In hill-selection work the progeny of plant B should be saved

the multiplication of the selected strains for field planting and the elimination of weak plants.

HILL SELECTION

The hill-selection method consists in marking the most promising plants during the growing season and at harvesting time saving only those that give the greatest promise. (Figs. 5 and 6.) The progeny of each hill should be kept separate and the same data taken as outlined for the tuber unit. Plant on the tuber-unit or progeny-row basis the following season. For the sake of uniformity a definite number of tubers (five or more) should be planted from each hill selection. Subsequent procedure should follow the methods given for tuber-unit work.

MASS SELECTION

Mass selection differs from hill selection in only one respect, which is that the tubers from the individually selected plants are not kept separate. Generally those who practice mass selection do not go to the trouble of marking promising individual plants during the growing season, but simply go through the field before harvesting the whole crop and dig by hand as many plants as may be desired to secure the necessary quantity of seed that show the desired vigor and stem characters thought to be correlated with productiveness, trueness to type, and uniformity in size of tubers of the particular variety grown.

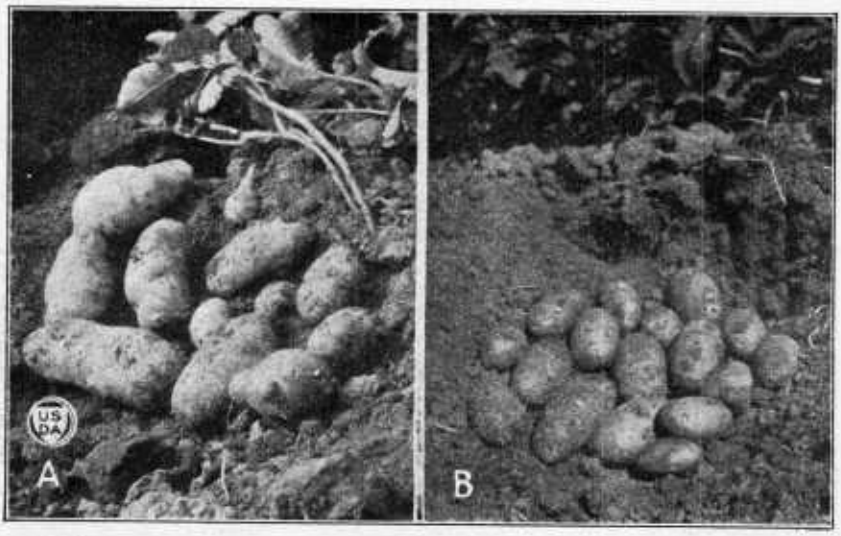

FIGURE 6.—Progeny from abnormal (A) and normal (B) plants of the Russet Burbank potato. Plant A is known in the West as a degenerate or run-out plant, and the disease with which it is affected is probably identical with that recently termed "spindle tuber." It is a communicable disease and may become serious. In hill-selection work the progeny of plants such as B should be saved

FIELD ROGUING

Improvement of the seed stock through field roguing consists in the removal of all diseased, weak, off-type, or varietal-mixture plants during the growing season. The successful removal of such plants does not necessarily involve an intimate knowledge of the various diseases affecting the potato, but it does require that the person doing the roguing be able to tell whether a plant is normal or abnormal in appearance. A sufficient field area should be rogued the first year to provide the quantity of seed necessary to plant the full acreage to be grown the ensuing season. The area to be rogued should be gone over at least three times during the growing season, to insure the removal of all plants affected with transferable diseases, such as mosaic and leaf roll, as soon as their presence can be detected. In the field-roguing method no attempt is made to select the progeny of individual plants at harvesting time, the whole crop being dug and all desirable seed stock gathered and stored in bulk.

STRAIN TESTING

The improvement of seed potatoes by the strain test, or, as it might more properly be termed, the "source-of-seed test" method, consists in securing as many desirable lots as possible of seed stock of the same variety from different growers throughout a given district or State, or even from various States, and carefully studying their behavior when grown side by side under identical soil and cultural conditions. Experimental studies by this method of seed improvement have demonstrated that some lots or strains of seed stock are far superior to others; in fact, differences in yield of more than 100 bushels per acre have been noted between the lowest and the highest yielding strains. Furthermore, it has been conclusively demonstrated by numerous trials that these yields were not accidental, but that in practically every instance the high-yielding strains have consistently given larger yields wherever tested.

The improvement of seed stock by this method does not consist in the actual isolation and development of a strain from a given variety, but rather in locating, as it were, by comparative tests the really superior sources of seed stock. The actual improvement accomplished is measured by the success attending one's efforts in getting live, up-to-date growers to discard their inferior strains and purchase the superior one, as shown by the tests made.

The practical operation of such a movement may be emphasized by stating that in 1921 more than 100 potato growers in Wisconsin grew seed stock of a superior strain of Triumph potatoes located in this manner in 1918.

It should be remembered that, whatever selection practice is pursued, the fields devoted to the production of high-quality seed must be carefully rogued if the vigor of the seed stock is to be maintained.

RELATIVE MERITS OF PRECEDING PRACTICES

A careful consideration of all the experimental evidence at hand would seem to justify the conclusion that in the hands of an especially trained individual the tuber-indexing method is without doubt the most effective for the elimination of diseased tubers and for the creation of foundation stock from which to produce high-class seed stock. The tuber-unit method is the next most promising procedure to follow. When the tuber-unit method is practiced in connection with that of hill selection it should prove much more effective than when used in connection with bin-selected stock. The first three methods can be recommended only to those growers and specialists who are capable of giving the necessary thought and time to produce results. Mass selection and field roguing present greater possibilities in the hands of the average grower who does not have the time or the inclination to give the care that is required for best results. Strain testing is not generally possible to the commercial grower.

REQUIREMENTS FOR SUCCESS

The only requirements for the successful practice of the tuber-unit, hill-selection, and mass-selection methods of seed-potato improvement are a reasonable degree of painstaking effort on the part of the grower, some 12-inch garden labels, a small pair of balances,

a sufficient number of small sacks, and a safe place in which to store the selected tubers until required for the next season's planting. In addition to this, the grower should have a breeding plot in which each season's selections can be developed up to the point of field-planting stock. This selection or seed plot should be located at as great a distance from the commercial potato field as possible, in order to secure the greatest degree of isolation that is feasible.

ISOLATION

Heretofore the problem of isolation has not received due consideration. This was largely owing to the fact that the seriousness of such diseases as mosaic, leaf roll, curly dwarf, streak, and spindle tuber has only recently come to be recognized. The fact that all of these diseases are readily transmitted from diseased to healthy plants through the instrumentality of plant lice or aphids and the further fact that as yet there is no reliable information as to the distance that insects may transport these diseases suggest as complete isolation of the seed plot as possible.

The latest suggestion in regard to the production of seed potatoes under isolation is that each variety be grown separately, as it has been found that stock of certain varieties supposed to be free from mosaic have served as disease carriers to more susceptible varieties. For example, it is not desirable to grow the Irish Cobbler adjacent to the Green Mountain intended for certification, as the former may carry the mosaic virus without expressing it. The danger from contamination of the healthy Green Mountain strain by the Irish Cobbler is considered sufficiently great by some seed-certification agencies to cause them to refuse to consider stock thus grown as eligible for certification. The ultimate success of the seed plot in so far as the elimination of tuber-borne diseases is concerned rests largely upon the ability of the grower to recognize diseased plants and the promptness with which they are removed from the seed plot and destroyed. Frequent and thorough inspections of the seed plot are necessary to insure the largest possible reduction of diseased plants and to reduce the transmission of disease from diseased to healthy plants.

SEED TREATMENT

It is impossible to produce high-grade seed potatoes if the seed planted is infected with disease organisms capable of infecting the crop. The disinfection of the seed potatoes is therefore necessary if the best results are to follow. The two diseases for which seed potatoes are ordinarily treated are common scab and black scurf, or Rhizoctonia. The two disinfecting agents recommended for such treatment are formalin and corrosive sublimate (mercuric chloride, or bichloride of mercury). Formalin is a trade name for a 40 per cent solution of formaldehyde gas. Corrosive sublimate is a white crystalline poisonous compound which goes into solution very slowly in cold water but is readily dissolved in boiling hot water. In recent years the hot formaldehyde treatment of seed has been found to be much more effective against black scurf (Rhizoctonia) than the cold-solution

treatment, and it requires a much shorter period of immersion. The formulas recommended for these two disease disinfectants are as follows:

1. Formalin:
   a. Cold treatment:
      Formalin, 1 pint.
      Water, 30 gallons.
   b. Hot treatment:
      Formalin, 2 pints.
      Water, 30 gallons, heated to 125° F.
2. Corrosive sublimate, 4 ounces.
   Water, 30 gallons.

The period of treatment for formula 1, *a*, and for formula 2 is from 1½ to 2 hours when the seed is dormant and one-half to 1½ hours if the tubers are germinated. With formula 1, *b*, on account of the double strength of the solution and the higher temperature of the liquid, the period of treatment is cut to 4 or 5 minutes. In using the hot formaldehyde solution it is necessary to have a reliable thermometer and a well-controlled method of maintaining a uniform temperature throughout the treatment.

The treated tubers should on no account be allowed to come in contact with such receptacles as old sacks and barrels in which diseased seed has been handled, as these articles are almost certain to be sources of reinfection.

PREPARATION AND FERTILIZATION OF THE SOIL

Strong, vigorous plants can not be produced on land that has been poorly prepared or that is deficient in available plant food. Seed potatoes should be grown on land that has been deeply plowed and thoroughly prepared to receive the seed. It should be well supplied with organic matter and available plant food. A clover or alfalfa sod furnishes the organic matter and considerable of the plant food. Barnyard manures or commercial fertilizers, or both, will supply the additional plant food necessary to produce a good crop.

CAREFUL CULTURAL PRACTICES

The vigor of the seed stock produced is to a large extent dependent on the care given to the growing crop. Uniformity in the size of the tubers is to a large extent governed by the rate of planting. Closer planting should be practiced in the growing of seed than of table stock. Some growers in Aroostook County, Me., space their rows from 32 to 36 inches apart and the plants in the row 8 to 12 inches. The crop should be cultivated as frequently as may be necessary to provide the most suitable growing conditions.

Every effort should be made to protect the plants from injury by insect or fungous pests. Leaf-eating insects can be effectively controlled if the plants are thoroughly sprayed with arsenical poisons; sucking insects, with contact solutions, such as kerosene emulsion and nicotine; and fungous diseases, such as the early and late blights, with Bordeaux mixture. In every operation it should be remembered that whatever contributes to the health of the plant increases the vigor of the seed stock produced.

ELIMINATION OF VARIETAL MIXTURES AND DISEASED OR WEAK PLANTS

The vegetable-seed growers employ the term "roguing" to denote the process of removing all mixtures or off-type plants from the seed plot. As this term, when understood, is a brief and yet sufficiently descriptive way of indicating the process of eliminating all undesirable plants or "rogues," it is proposed to use it in this connection.

It is an easy matter to rogue a seed-improvement or selection plot during the growing season. Varietal mixtures are more easily detected when the plants are in bloom. Weak plants are usually apparent in the early stages of their growth, as are also certain types of diseases, such as mosaic and blackleg, although both may appear later. Plants infected with Rhizoctonia and Fusarium are usually not apparent until the latter part of the growing season. It is evident from these statements that in order to rogue the seed plot thoroughly it is necessary to make two or three examinations of the field or plot during the growing season. Further roguing should be done when the crop is harvested by discarding the progeny of all low-producing plants. (Fig. 5, A.)

MONETARY VALUE OF GOOD SEED POTATOES

The producer of high-grade seed potatoes is justly entitled to a fair monetary return for the special efforts he has made to produce quality seed stock. This is especially true where a seed plot is maintained year after year and the crop has been officially inspected and passed by a duly authorized seed-certification inspection officer. Just what increase in price over ordinary stock one is entitled to receive for such efforts and for the inspection fees involved is not an easy matter to determine. It is believed that a premium of 50 cents a bushel over the market price of table stock of the same variety is ordinarily sufficient to amply repay the grower. Opinions, however, will differ upon this point. At the present time, the price of certified seed stock varies all the way from $1 to $3.50 a hundredweight—60 cents to $2.10 a bushel.

IMPORTANCE OF TUBER SHAPE

Reasonable trueness of the tubers to varietal type is generally demanded by the purchaser of certified seed. Most writers who have dealt with the subject of good seed have always placed strong emphasis upon the importance of its being true to type. Rather recently, however, some scientific as well as practical growers have been disposed to regard tuber shape as being of less importance than has been previously supposed. They have come to regard tubers that have departed from the type as a result of unfavorable environmental conditions as being satisfactory for seed purposes.

As a result of a long-continued preachment of the undesirability of slightly off-type tubers for seed purposes, many cars of otherwise high-grade seed stock have been annually rejected by southern truck growers. This is particularly true in the case of conspicuously flattened and somewhat elongated tubers of the Irish Cobbler variety. The Irish Cobbler grower in the South has come to demand roundish

tubers and is suspicious of the purity of seed stock containing flattened and somewhat elongated tubers and generally protests their acceptance as strictly first-class seed stock. In fact, he is inclined to regard the off-type tubers as Green Mountain. The only obvious way of correcting these firmly rooted convictions is to demonstrate experimentally that off-type tubers resulting from unfavorable soil, cultural, or climatic conditions are no more likely to produce off-type progeny than are normal-shaped ones. This statement, however, does not apply to off-type tubers resulting from disease; such tubers should not be planted. The spindle tuber recently recognized by pathologists as a communicable disease is very similar in its method of transmission to leaf roll and the mosaic disease. Figure 6, A, represents a fairly good example of spindle tubers. It is important, therefore, in the purchase of somewhat off-type seed potatoes to know whether the change in shape is really due to unfavorable environmental factors and not to disease.

CAREFUL HARVESTING AND STORAGE OF THE CROP

The average grower does not fully appreciate the importance of using every means to prevent the mechanical injury of the tubers during the process of harvesting and storing. If the crop is grown on land containing a plenteous admixture of small stones, the tubers are almost certain to be more severely injured in harvesting than when grown in a sandy loam soil. Hand digging is not always feasible, but it is believed that where small stones abound in the soil it will be desirable to harvest the home seed plot by hand. Much injury will be avoided if the seed stock designed for planting the field plot of the ensuing year is picked directly into crates in which it is allowed to remain throughout the storage period.

The storage conditions necessary to insure vigorous seed at planting time are more easily provided in the North than in the South. In the former region a well-constructed cellar, pit, or cave serves reasonably well. The main thing is to keep the room temperature sufficiently low to retard germination. The ideal seed tuber is one that has not wasted any of its stored-up energy by excessive loss through sprouting. (Fig. 7.) It should be firm, with the first sprouts just showing. Such tubers can be depended upon, if suitable conditions prevail, to start quickly when planted and to make a vigorous growth.

The general practice among southern growers of securing seed from the North involves, in the absence of suitable storage conditions, one of two things: Either getting the seed potatoes late in the fall and holding them over in dugouts, pits, or cellars, with consequent sprouting before planting, or the risk of having the seed chilled, frozen, or overheated while in transit in midwinter. In the writer's opinion the greatest need of the large southern truck grower at present is suitable storage facilities for handling fall shipments of seed potatoes. As a purely economic matter the proposed change ought to commend itself. In probably nine cases out of ten the difference in first cost of these potatoes as between fall and midwinter shipments would more than offset the extra cost of storage,

while the added security from danger of chilling or freezing the shipment would still further compensate the grower.

For further particulars on storage, consult Farmers' Bulletin 847, "Potato Storage and Storage Houses."

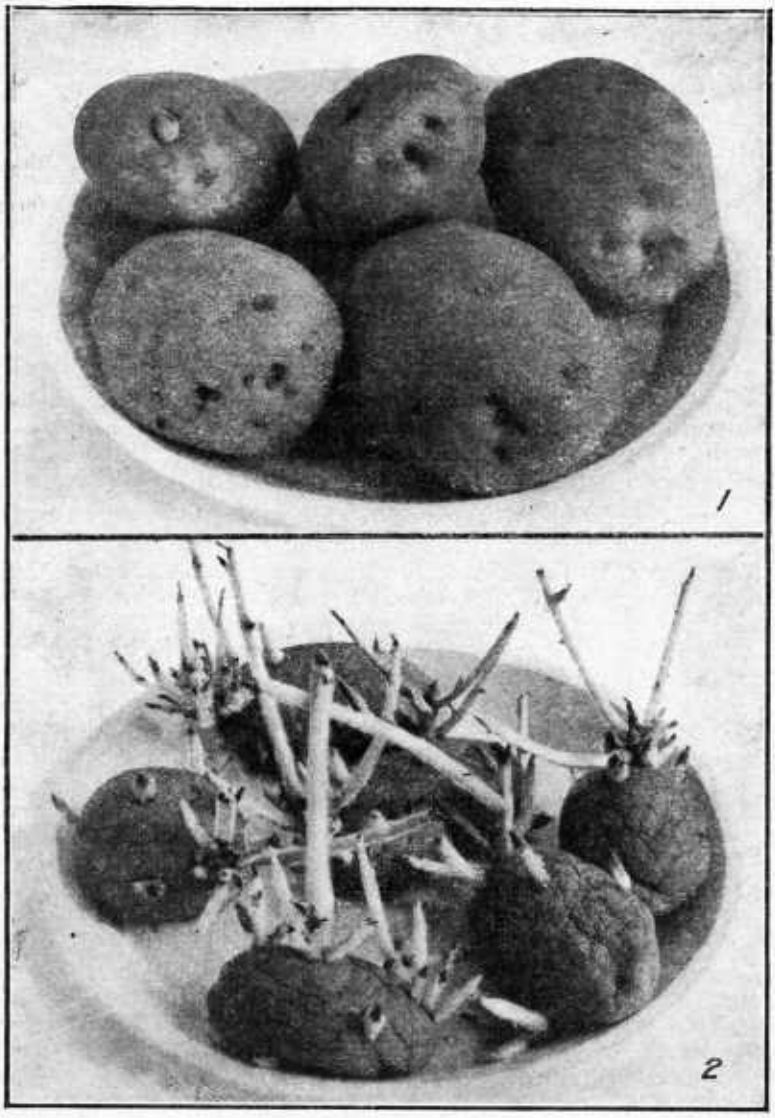

FIGURE 7.—Potatoes for seed purposes, showing different stages of germination: 1, Desirable; 2, undesirable

LARGE COMPARED WITH SMALL SEED TUBERS

In seasons of short production and consequent high prices for table stock, the question is frequently raised as to the advisability of using the small unsalable tubers for seed. The answer to this question

is that it is always unsafe to use small tubers for seed purposes unless one is absolutely certain that they have been produced by healthy, vigorous, and productive plants. As a result of some experimental study of this question by Ballou and Gourley[4] it was found that the use of large tubers gave—

(1) A very heavy, perhaps almost total, percentage of the high-producing strains.
(2) A heavy percentage of the average or moderate-yielding strains.
(3) A very small percentage of the inferior or low-producing strains.

The use of small potatoes gave—

(1) A very insignificant percentage of the superior or high-yielding strains.
(2) A small percentage of the average or moderate-yielding strains.
(3) A very heavy, almost total, percentage of the low-yielding or inferior strains.

The use of small seed potatoes is permissible only when they are known to have been produced by strong, healthy, and productive plants. It is never advisable to use small tubers from the general mass produced from unselected stock.

WHOLE COMPARED WITH CUT SEED[5]

Considerable attention has been paid to the subject of whole compared with cut seed at various times by the State agricultural experiment stations. The data accumulated in these investigations are for the most part conflicting in so far as they pertain to the use of whole seed. In general, the data show that within reasonable limits the larger the seed piece planted the larger is the crop produced. English and Scotch potato growers almost without exception plant whole tubers. The seed used usually runs from 1¼ to 2¼ inches in diameter, being screened out of a crop which as a rule has been grown especially for seed purposes. They are harvested before they are mature, and but a relatively small proportion of the crop exceeds the size mentioned. These growers believe that an earlier and more vigorous growth is secured from immature tubers.

Some of the reasons why European growers have adopted whole seed and are succeeding in producing profitable crops are as follows: (1) They are assured of an almost perfect stand; (2) there is greater freedom from disease; (3) the almost universal practice of germinating their seed before planting insures a minimum number of sprouts; and (4) the greater fertility of their land makes large yields of medium-sized tubers possible.

Some of the reasons for failure in the use of whole seed in this country are: (1) The use of small tubers from unselected stock and (2) the development of too many sprouts, with a consequent large set of tubers, which, owing to lack of thorough preparation of the soil, to scant plant food, and to insufficient moisture, do not reach a marketable size, at least in sufficient numbers to produce a profitable crop. The development of too many sprouts comes about through planting tubers in a dormant condition, which under favorable soil temperature and moisture starts almost every bud into growth.

[4] BALLOU, F. H., and GOURLEY, J. H. I. THE STATUS OF THE POTATO-GROWING INDUSTRY IN OHIO. II. SEASONAL NOTES ON POTATOES. Ohio Agr. Exp. Sta. Bul. 218, p. 587. 1910.

[5] STUART, W., and others. SIZE OF POTATO SETS: COMPARISONS OF WHOLE AND CUT SEED. U. S. Dept. Agr. Bul. 1248, 43 pp., illus. 1924.

Scotch and Irish potato growers plant not less than 37 bushels of seed per acre, and frequently this quantity is greatly exceeded. The American grower, on the other hand, plants from 7 to 16 bushels per acre, with an average of 9 to 11 bushels. It is believed that the average potato production of the United States would be very materially increased if a larger quantity of seed were used.

SUMMARY

The production of high-grade seed potatoes should be regarded as a special business.

Good seed is a determining factor in the production of maximum crops of potatoes.

Certified seed is generally superior to noncertified seed.

Good strains of seed may be obtained by the tuber-unit, tuber-index, hill-selection, mass-selection, field-reguing, or strain-test methods through the process of elimination.

Like produces like. If tubers from unproductive, weak, or diseased plants are planted, a poor harvest will be reaped. Use seed from productive plants.

Purity of seed stock is an essential quality of good seed. Serious losses are sustained by the grower through mixtures.

Good seed can not be produced unless the growing plants are well cared for and the strain of seed planted was a good one.

A more liberal use of good seed would materially increase the average production per acre.

All seed should be disinfected before planting.

Experimental evidence does not indicate that whole seed is superior to cut seed, at least so far as it relates to the United States.

Good storage facilities are essential to insure sound, firm seed at planting time.

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